VALIDATION AND COMPARISON OF TWO SENSORY PERCEPTUAL EXAMINATIONS

An abstract of a thesis by
Pamela Sue Armstrong
June 1978
Drake University
Advisor: James Whitehouse

The problem. Inaccurate diagnosis of brain damaged and non-brain-damaged subjects when utilizing sensory perceptual examinations may be due to a lack of standardized administration procedures. The purpose of this study is to provide validation data for the Reitan-Klove Examination and evaluate an alternative standardized testing procedure which is based on subtests similar to the Reitan-Klove Examination.

Procedure. Von Frey hairs, tuning forks, calipers, wire numbers, and raised designs were used for standardization. The control group consisted of 11 male and 23 female hospital staff members with a mean age of 40 years. The experimental group consisted of one female and 33 male brain-damaged patients with a mean age of 49 years.

Findings. The procedures were compared on the occurrence of false positives and false negatives. Both procedures yielded no false positives and a small incidence (6%) of false negatives; both procedures were valid. Subtests involving the same variables were then compared. The comparison revealed that in the area of tactile perception and fingertip number writing perception, the discriminative validity of these tests was increased by procedural standardization.

Conclusions. There are indications which suggest that procedural standardization could increase the validity of sensory perceptual examinations.

Recommendations. Further research on this issue incorporating less severely brain-damaged and psychotic subjects is suggested in an attempt to provide more information regarding procedural standardization.

VALIDATION AND COMPARISON OF TWO SENSORY PERCEPTUAL EXAMINATIONS

A Thesis

Presented to

The School of Graduate Studies

Drake University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

---

by

Pamela Sue Armstrong

June 1978

VALIDATION AND COMPARISON OF TWO SENSORY PERCEPTUAL EXAMINATIONS

by

PAMELA SUE ARMSTRONG

Approved by Committee:

James H. Whitehouse
Chairman

R. Michael Latta

Marjorie Prentice

Earle L. Canfield
Dean of the School of Graduate Studies

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (continued)

CHAPTER 1

INTRODUCTION

One of the many skills expected of the practicing clinical psychologist is expertise in assessing an individual's behavior. Presumably, the psychologist should be able to tell if an individual has a tendency to become depressed or if another individual can successfully complete college. Obviously this expectation can be somewhat unrealistic. However, psychologists have attempted to develop tests or measurement systems that have descriptive values on a number of dimensions ranging from musical talent to indications of a need for psychotherapy. Of particular concern to the clinical psychologist has been the continuing demand for differential diagnosis through psychological testing.

Differential diagnosis is based on the difference in test performance of groups of subjects, such as brain damaged and non-brain-damaged, which reveal specific patterns of scores characteristic of each group. Differential diagnosis is important because accurate diagnosis has implications for both treatment and prognosis. It is critically important to separate subjects with a behavioral problem from those with potentially significant organic problems such as brain tumors.

With a variety of tests from which to choose, the clinical psychologist has to resolve the question of which tests to utilize to assess the brain-behavior relationship. The clinician's concept of brain function influences the decision of which test to utilize. There are basically two approaches to brain function assessment: "organicity" and multiple function analysis.

ORGANICITY

A few years ago, all clinical psychology training included an introduction to the crude tools of assessement such as the Bender-Gestalt and the Graham-Kendall tests (Matarazzo, 1972). Psychologists were trained to use these tests whenever the possibility of the vaguely described clinical conditions of brain damage was suspected from the patient's history, clinical signs, or symptoms.

The concept of organicity was a unitary approach which assumed that all brain damage leads to similar behavioral effects and the behavioral differences among those brain damaged persons were due primarily to the severity of the damage and the premorbid characteristics. The concept of organicity evolved mainly as the result of two factors.

Therapy orientation was a factor influencing the concept of organicity. Since the main method of dealing with various behavioral pathologies was based on psychotherapy and psychoanalysis, it becomes important for the therapist to know which clients would benefit from this treatment. If the behavior pathology resulted from

structual damage, the methods of psychoanalytically oriented treatments were, theoretically, useless as therapeutic agents. Therefore, since behavior pathology which resulted from brain damage was outside the theoretical scope of the treatment orientation, it was important to be able to identify the brain damaged individuals as patients with poor therapeutic prognosis. It would be most convenient for the therapist to have a quick and easy way to screen clients for therapy. Thus emphasis was placed on developing a test that would reflect brain damage. There was no theoretical interest in discovering the brain-behavior relationships that occurred with brain damage and developing tests for this purpose was not encouraged while the search for the single best indicator of brain damage continued.

A second factor contributing to the development of the concept of organicity was Goldstein's concept known as impairment of the abstract attitude. Goldstein (1939) found commonalities exhibited in clinical syndromes of traumatically brain damaged humans which he described as impairment of the abstract attitude. Goldstein also described the variable effects of brain lesions which seemed to depend on their etiology and location. Since the idea of generalized organic effects seemed more concise, it had a strong influence upon clinical psychologists' views on assessment of brain damaged humans. If, according to the

organicity concept, brain lesions produced substantially the same qualitative effects regardless of its etiology, location, and duration, then the task of the psychologist becomes one of developing a single, highly reliable, sensitive, and otherwise valid measure of those effects (Lezak, 1976).

MULTIPLE FUNCTION ANALYSIS

Another concept of brain function assumes that there are several different specific abilities. Thus, in order to evaluate the state of the brain, a number of specific tests must be developed and used. This concept was based on research by Teuber (1959; Teuber, Battersby, & Bender, 1960; Semmes, Weinstein, Ghent, & Teuber, 1960) and Reitan (1955, 1962, 1966, 1974) to name a few. Such researchers used empirically based evidence to question the unitary concept of "organicity".

After many studies in the area of assessment of the visual and somatosensory functions, Teuber concluded that specific systems mediate not only their own activity but other activities as well and that the highest levels of neuronal control require the interaction of both. To assess the extent of damage to a system, testing must not only include the system itself, but must involve the other systems which interact with the first system.

PROBLEMS IN ASSESSMENT

One problem in assessment of brain-behavior relationships is that the label of "brain damage" is vague. It seems to be a catch-all phrase for any brain dysfunction from cerebral palsy and mental retardation to damage caused by a penetrating missile wound. The term does not take into account criteria such as rate of brain tissue destruction, accuracy of the locus, magnitude of the lesion, age, initial and subsequent effects on surrounding tissue and cerebrovascular system or age and premorbid capacities of the patient. Then by studying a population labeled "brain damaged" without regard to the above criteria, it follows that the research, in assessment of brain-behavior status, will be inconsistent since there is no definition of parameters placed on the dependent variable, brain damage (Smith, 1969). It is important to verify the extent and type of brain damage. Behavioral correlates with EEG tracings, angiograms, and autopsy are some of the methods by which this can be done. It is also more complicated to collect data when the research is based only according to broad diagnostic categories. Decisions based on these categories are characterized more by disagreement than by agreement in findings (Reitan, 1962).

Another problem in assessment is inadequate sample of different behaviors to form an overall picture of the functional status of the brain. As a result, premature

generalizations about behavior are made which, in many cases, are incorrect diagnoses. Reitan (1974) overcame the problem of inadequate sample by emphasizing the use of standard batteries of tests designed to reflect the full range of deficits associated with brain lesions. This group of standardized tests was administered as a unit and samples a wide range of behaviors. All of the scores were evaluated and the interrelationship of patterns of scores was the basis of diagnosis. The interrelationship of patterns of scores was based on generalizations derived from experimental investigations of many examples of a certain deficit. These generalizations were not based on some abstract concept of brain function. What seems logically to be involved in a certain deficit is not always involved. For example in Teuber's (1959) orientation study, it would seem logical that the tactual modality was involved in following tactual maps, but it was also noted that the visual modality was involved. Therefore, Reitan was trying to develop a valid test by looking at the overall brain-behavior relationship by having a large sample of behaviors to use as empirical data. The process used to gather data was a systematic and ordered investigation of the variables which would help in the interpretation of data. A large sample of behaviors should be taken from each subject and a large number of subjects should be assessed before any diagnosis based on patterns of deficit can be made.

INTENT OF ASSESSMENT

The intent of assessment was a detailed appraisal and description of a subject's condition. Behavior can be assessed by placing the subject with known lesions in many different situations. The effects of manipulation of these variables or situations should be considered in the context of the brain pathology. Also to be considered would be the need for investigation of possible differential effects of various types of brain pathology. The brain damaged subject's performance should be compared to a group of non-brain-damaged subjects. The differences in performance should reveal specific patterns of deviation. The brain damaged group should vary from what was considered the normal, or non-brain-damaged, group to a significant degree on tests that could be used for differentiating brain damaged persons from non-brain-damaged persons. This was the basis of differential diagnosis. With large samples of behavior based on manipulation of variables and brain pathology, conclusions can be made based on the correlates of the brain-behavior relationships.

DEVELOPMENT OF REITAN-KLOVE EXAMINATION

In the course of trying to predict type and localization of cerebral lesions by the use of the Halstead's Battery and the Wechsler-Belleve Scale, Reitan used additional measures of a simple nature which would reflect the adequacy of sensory perceptual performance on both sides of the body.

These tests were not original tests, they have been used by neurologists for years. By using these tests in addition to tests of higher brain function of an intellectual and cognitive nature, the clinical significance of these neurological tests was augmented. Hallgrin Klove contributed to the development of Reitan's improved test in terms of content and scoring procedure. Together they developed the Reitan-Klove Sensory-Perceptual Examination which is a standard part of the Halstead-Reitan Test Battery.

The purpose of the Reitan-Klove Sensory-Perceptual Examination was two-fold. First, it could be used to determine whether or not specific instances of errors in perception which occurred were of the type that were rarely manifested by persons with evidence of normal brain functioning. Second, it could be used to compare the performance on the two sides of the body in order to provide additional information regarding the comparative integrity of the two cerebral hemispheres. A sensory-perceptual examination reflects the method of inference which should include the following criteria: the level of performance, specific deficits of pathognomic significance, differential scores or pattern of abilities, and it should provide a comparison of the functional efficiency of both sides of the body (Reitan, 1974). The Reitan-Klove Examination, in my opinion, only approximates these criteria. Reitan and Klove based their system of diagnosis on empirical data gathered from testing groups of non-brain-damaged subjects and brain damaged

subjects. Their data provided a basis for determining a diagnosis of "normal" or "brain damaged" using the previously outlined criteria; however, these data are as yet unpublished. There is evidence to suggest that the Reitan-Klove Examination does not differentiate well between normal and brain damaged subjects. Boll and Reitan (1972) found that the Reitan-Klove Examination failed to discriminate between children with and without cerebral lesions on the following subtests: (1) left and right hand tactile form recognition; (2) fingertip number writing perception; and on (3) the left hand tactile finger localization test. Evidence such as this leads the author to question the discriminative validity of the Reitan-Klove Examination.

Lack of standardization of procedural administration on the Reitan-Klove Examination may affect the validity. The reason for administering a standard predetermined set of tests is to permit evaluation of the adequacy of this set of tests in reflecting individual variations among brain conditions. If the tests were not administered in the same carefully systematic fashion to all patients, equivalent information may not be obtained from each patient; and the obtained scores could not be compared to the empirical data upon which diagnoses were made. Only if each patient receives exactly the same test administered in exactly the same way can the obtained scores be usefully compared to the empirical data resulting in accurate diagnosis. Many of the Reitan-Klove subtests are not standardized in procedural

administration.

The subtests in the Reitan-Klove Examination include: tactile imperception, finger agnosia, fingertip number writing perception, coin recognition, tactile forms recognition - time and errors, auditory and visual imperception. The complete directions for each subtest will be presented in the procedure section of Chapter II. The following paragraphs suggest improvements for each subtest of the Reitan-Klove Examination which would result in procedural standardization.

TACTILE PERCEPTION

The tactile imperception subtest involves more than threshold testing, or whether the system is functioning properly; it involves thresholds, peripheral nerve intactness, and central processing which is tested by suppression. Suppression is the syndrome which consists of the extinction or obscuration of the perception of stimuli, in this case touch, on the "affected" hand when stimulation is presented simultaneously to the other "normal" hand (Reider, 1946). Studies have indicated that subjects with lateralized lesions often identify unilateral stimulation correctly but fail to identify bilateral simultaneous stimulation to the hand contralateral to the damage (Reitan, 1974). Information such as this will aid in localization of the damage. Suppression indicates maximum involvement of the area posterior to the Rolandic fissure. Absence of suppression is evidence against an

acute destructive lesion in the right posterior hemisphere. Evidence indicating a rapidly developing infiltrating lesion can be inferred from greater suppression on the right hand as compared with the left (Reitan, 1974). More suppression occurs as a result of right hemisphere lesions than from left hemisphere lesions. Inconsistent suppression on both sides with bilateral simultaneous stimulation or suppression of ipsilateral simultaneous stimulation indicates severe and diffuse damage in both hemispheres.

It seems that the tactile imperception test is not a specific simple reflex; this information must be integrated. An essential condition for integration is interaction between all parts of the system. This implies that centralization, the notion that each sensation projects to its own specific association area, is not correct. Tests that would tap more than thresholds and might approach integration would include pressure sensitivity and two point discrimination (Semmes, Weinstein, Ghent, & Teuber, 1960). Studies with these tests indicate that single defects of either hand are not produced by contralateral sensiomotor lesions more frequently than by other lesions in areas unrelated to locus of injury (Semmes, 1968).

However, multiple defects of the right hand were associated with left sensiomotor lesions or with lesions of the precentral, postcentral, or posterior parietal subsector of this region (Semmes, 1968). Multiple defects of the left hand occurred more often after lesions of the post-

central and posterior parietal subsectors of the right sensiomotor region rather than after lesions elsewhere in the brain. Lesions of the left sensiomotor region were more commonly followed by defects which involved the ipsilateral hand, with or without concomitant defect of the contralateral hand, than by defects which were strictly limited to the contralateral hand. The reverse was true following lesions of the right sensiomotor region. This information could be used to help localize lesions.

FINGER AGNOSIA

Tests of finger agnosia should tap some integrative processes, because the finger touched has to be identified. It seems that the integration would occur between tactile and verbal processes. There is no specification for the stimulator to be used. It could be wide or narrow, smooth or rough, sharp or blunt. According to Verillo (1975), all of these variables could make a difference in perception. To make the test more standardized in procedural administration and to control for the variance in stimulators, the author suggests the use of von Frey hairs as stimulators.

FINGERTIP IDENTIFICATION

In the fingertip number writing perception subtest, the stimulator is not specified. The amount of skin stimulated is also variable depending on how large or small the examiner writes the numbers. Verillo (1975) states that the amount of area stimulated affects the perception. To control these variables, the author proposes using numbers

the size of the fingertips and made of wire. The subject will be able to explore the number using only the indicated fingertip to identify the number.

TACTILE IDENTIFICATION

Both the coin recognition and tactile form recognition tests seem to be designed to detect deficit in integration at a higher level than the other tests in the Reitan-Klove Examination. Vision is restricted in both tests; perception depends entirely upon tactile systems. There must be some integration between the systems of tactile and form to identify the objects. The author suggests a more direct approach to tapping these functions would be in a test using abstract raised designs which must be identified by matching the sample design with the comparison design. Vision would be restricted in this test also.

AUDITORY PERCEPTION

The auditory subtest appears to be a threshold test, although auditory suppression can be used to indicate maximum damage in the temporal lobe contralateral to the stimulation (Reitan, 1974).

There is evidence that many subcortical stations respond to a steady tone such as a tuning fork (Verillo, 1975). From this, it could be inferred that a steady tone would be more reliable than varying tones (fingers) in evoking cortical responses. Standardization in procedural administration can be introduced to this test by using a tuning fork instead of the fingers as a stimulus. Tuning forks are

readily available to most clinicians so the cost, time and money for standardization is minimal.

The intent of this paper is to evaluate the Reitan-Klove Sensory-Perceptual Examination as a discriminator between normal subjects and those subjects with brain damage. One way this can be done is to check the validation data. Since the original validation studies are unpublished, new validation data will be obtained. In addition an alternate examination, the Armstrong-Whitehouse Sensory-Perceptual Examination, will be evaluated for assessing sensory perceptual status based on the variables of the Reitan-Klove Examination. The Armstrong-Whitehouse Examination is more standardized procedurally than the Reitan-Klove Examination. If there is any difference between the two tests' discriminative validity based on the occurrence of misclassification of subjects by the examinations, it would suggest that the Reitan-Klove Examination should have a more standardized procedural administration to improve its discriminative validity.

CHAPTER II

METHODS

SUBJECTS

The subjects were drawn from patients and staff at a midwestern Veterans' Administration Hospital. There were 34 subjects in each group of brain damaged and non-brain-damaged individuals. In the control or non-brain-damaged group, the subjects consisted of 11 males and 23 females. The subjects of the experimental or brain damaged group consisted of 33 males and one female. The age of the control group ranged from 25 to 64 years with the mean age being 40 years. In the experimental group, the age ranged from 28 to 63 years with the mean age 49 years.[1]

The experimental group consisted of subjects that were medically diagnosed brain damaged. A medical diagnosis of brain damage was based on one or a combination of the following: brain scan, craniotomy, angiogram, EEG tracings, and physician's diagnosis. The experimental group's medical diagnoses are listed in Table 1.

---

[1]The author assumes that age and sex differences between the control and experimental group were unrelated to these tests.

Table 1

The medical diagnoses of the experimental group.

Diagnoses	Number of subjects
Non-Psychotic Organic Brain Syndrome	
Cerebral Vascular Accident	10
Head Trauma	2
Alcoholism	2
Pseudobulbar Accident	1
Multiple Sclerosis	1
Brain Stem Damage	1
Brain Trauma	2
Korsakoff's	2
Anoxia	1
Cerebral Palsy	1
Huntington's Chorea	1
Encephalitis	1
Epilepsy	2
Psychotic Organic Brain Syndrome	
Brain Trauma	5
Organic Brain Syndrome	
Gunshot Wound	1
Chronic Brain Syndrome	
Head Trauma	1

The control group consisted of staff members who responded to a notice for volunteers to participate in a sensory perceptual research project. The subjects had no medical evidence of brain damage but could have had peripheral nerve damage. These subjects were paid five dollars for participating in the experiment.

APPARATUS

In the following paragraphs, the apparatus for each subtest will be described.

PRESSURE SENSITIVITY: Eleven nylon monofilaments were used which were modeled after the monofilaments used by Semmes et al. (1960). The grams of pressure for the monofilaments ranged from .051 grams to 18.200 grams (see

Table 2). Each nylon monofilament was embedded at one end in a wooden dowel handle 75 mm in length. The free end of the filament was 38 mm in length. The force required to bend each filament was measured by pressing only the tip of the filament against a chemical balance. The filaments were not allowed to touch the balance or the skin during the test at any point except the tip with this limitation: they were bent downward maximally.

Table 2

Grams of pressure for the monofilaments of the Pressure Sensitivity subtest.

Monofilament Identification Number	Grams of Pressure
1	.051
2	.143
3	.234
4	.722
5	1.525
6	1.930
7	2.660
8	2.860
9	5.650
10	6.150
11	18.200

FINGER AGNOSIA: A nylon monofilament was used as a probe to touch the fingertips. The monofilament used was the next in the series of monofilaments above the arithmetic mean of the subject's threshold, which was determined from the pressure sensitivity test. The subject's threshold was determined by taking the arithmetic mean of both series given in the pressure sensitivity test. For this subtest, the monofilament with the next higher pressure above the subject's determined threshold was used.

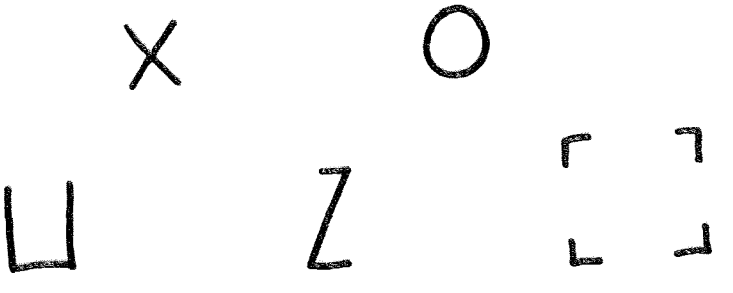
TWO POINT DISCRIMINATION: A pair of calipers manufactured by Lafayette Instrument Company were used. The calipers were constructed so that a single plastic point projected from the end. Along the side there were two plastic points, one fixed and the other variable. The two points can be separated up to five inches.

FINGERTIP NUMBER IDENTIFICATION: The numbers 3 through 6 were made of 18 Ga. copper wire of the size 20 mm by 10 mm and projected above the block by 5 mm. Each block was 5 mm by 4.5 mm by 1.7 mm.

RAISED DESIGN: The discriminanda were the five patterns shown in Table 3. The pattern was formed by 1 mm thick copper strips projecting 5 mm above a copper plate. Each plate was 36 mm on each side. A 70 mm long, 1¼ inch wide pipe was sodered to the back of the copper plate and filled with lead to obtain the weight of 495 grams for each stimulus as suggested by Ghent (1955).

Table 3

The patterns of the Raised Design subtest.



AUDITORY: Two tuning forks of 500 Hz. each were used. Black plastic goggles were used to assure the absence of visual modality involvement in the following subtests: pressure sensitivity, finger agnosia, two point discrimination, fingertip number identification, and raised design.

The test apparatus for the Reitan-Klove Examination consisted of the apparatus suggested and manufactured by Reitan.[2]

PROCEDURE

In the following paragraphs, the directions for both the Reitan-Klove Examination and the Armstrong-Whitehouse Examination will be presented.

TACTILE PERCEPTION

TACTILE IMPERCEPTION (Reitan-Klove): PUT YOUR HANDS ON THE TABLE LIKE THIS (palms down). I AM GOING TO TOUCH YOUR RIGHT HAND (touch) OR YOUR LEFT HAND (touch). I WANT YOU TO CLOSE YOUR EYES SINCE I WANT YOU TO DEPEND ONLY ON YOUR FEELING TO TELL ME WHICH HAND I TOUCH. IF I TOUCH YOUR RIGHT HAND (touch right hand), YOU SAY "RIGHT". THAT WAY I WILL KNOW YOU FELT IT. IF I TOUCH YOUR LEFT HAND (touch left hand) YOU SAY "LEFT". BE SURE YOU DO NOT MAKE A MISTAKE IN TELLING ME WHICH HAND I TOUCHED. DO YOU HAVE ANY QUESTIONS?

---

[2]Ralph M. Reitan, Ph.D., Neuropsychological Laboratory, University of Washington, Seattle, Washington, 98195.

Repeat or amplify the instructions as may be necessary to be sure that the patient understands the procedure.

First, touch the right hand or left hand in random sequence approximately four times each in order to determine the pressure needed to obtain consistent and correct responses to unilateral stimulation. Then touch right hand, left hand, or both hands simultaneously in random sequence until each has been tried at least four times. If the patient has more difficulty feeling the stimulus on one side or the other, this should be recorded.

The important point of this test, however, is to determine whether or not the patient fails to respond to one side consistently with bilateral simultaneous stimulation even though he responds correctly on the same side with unilateral stimulation. Never warn the patient that on some trials both hands might be simultaneously touched. Some patients have so much difficulty keeping their eyes closed that it may be necessary to blindfold them. Be sure that the responses are based upon tactile perception alone. Record only errors on the form.

Using the above procedure as a model, proceed with: NOW I'M GOING TO TOUCH EITHER YOUR HAND OR YOUR FACE, AND I WANT YOU TO TELL ME WHICH ONE I'M TOUCHING. JUST SAY HAND OR FACE. ALL RIGHT, CLOSE YOUR EYES.

Touch the right hand, left face, and both face and hand simultaneously in random sequence until each has been

done at least four times. Then repeat with left hand, right face, and both (Reitan, 1975).

PRESSURE SENSITIVITY (Armstrong-Whitehouse): The response to pressure sensitivity was measured on the center of the palm and the ball of the thumb of each hand. The S was shown the monofilaments and told that the S would be touched with some of them in order to determine the lightest touch the S could perceive. The S was told that some of the monofilaments may not be felt, but when touch was perceived on the indicated part of the hand, the S was to say touch. The S was instructed to put the goggles on and place the right hand, palm up, on the table. Each contact was applied for about one second with intervals of about three to eight seconds between applications. The monofilaments were applied in serial order, starting from different points below and above the expected threshold. Two determinations were made on each part in ascending and descending order. Record was made of the first monofilament perceived in each determination. The arithmetic mean of the values of these monofilaments were taken as the threshold. The same procedure was followed for the left hand.

TWO POINT DISCRIMINATION (Armstrong-Whitehouse): The ability to resolve two points was measured by a pair of calipers. The separation of the points could vary from 1/16 inch to two inches by 1/16 inch intervals. Measurement of the two point threshold was symmetrical about the center of the palm along the longitudinal and transverse axes. The

arithmetic mean of the two determinations of threshold in each direction, in ascending and descending order, was taken as the threshold for that axis.

The S was shown the instrument and told that the palm would be touched sometimes with both points and sometimes with only one. The S was instructed to put on the goggles and to respond, "One" or "Two" appropriately. Each contact was applied for about one second and about three to eight seconds were allowed to elapse between contacts. Care should be taken to apply the points with firm and equal pressure, in every instance the pressure was well above the S's pressure threshold. For each separation of the two points employed, four trials were given; on two of these trials, the S was touched with both points, and on the other two trials with only one point. The sequence of application of one or two points within each block of four trials was random. Correct responses on all four occasions were the criteria of resolution of two points at the given separation.

FINGER AGNOSIA

FINGER AGNOSIA (Reitan-Klove): I'M GOING TO TOUCH YOUR FINGERS, AND I WANT YOU TO TELL ME WHICH ONE I TOUCH. Examiner should hold test blank over the patient's forearm to block his vision and touch one finger or another. Immediately after a finger is touched the examiner should ask: WHICH FINGER DID I TOUCH?

The examiner must work out a system with the patient for reporting which finger was touched. Customarily the patient

will report by number, but sometimes the patient prefers to identify his fingers in other verbal terms. The patient should be permitted to use whatever method of verbal identification he prefers. Sometimes it is necessary to give the patient practice with his eyes open in order to be sure he is able to report reliably (Reitan, 1975).

FINGER AGNOSIA (Armstrong-Whitehouse): The S was instructed to place hands on the table, palms up. The experimenter explained "I'm going to touch your fingertips and I want you to tell me which one I touch." A finger was touched with a monofilament about the S's threshold and immediately after the touch the experimenter asked "Which finger did I touch?"

The experimeter must work out a system with the S for reporting which finger was touched. Customarily the S reports by number starting with the thumb as one through the small or fifth finger but sometimes the S should be permitted to use whatever method of verbal identification the S prefers. Aphasic Ss reported by wiggling the finger that was touched. Sometimes it was necessary to give the S practice with the eyes open in order to be sure that the S was able to report reliably. Before the test started, the S was asked to put on the goggles.

FINGERTIP IDENTIFICATION

FINGERTIP NUMBER WRITING PERCEPTION (Reitan-Klove): I AM GOING TO WRITE SOME NUMBERS ON YOUR FINGERTIPS. I WANT YOU TO PAY CLOSE ATTENTION SO THAT YOU WILL BE ABLE TO TELL ME

THE NUMBERS THAT I WRITE.

Illustrate on the subject's palm how the numbers will be written, as follows: THIS IS THE WAY I WILL MAKE A 3; THIS IS THE WAY I WILL MAKE A 4; THIS IS THE WAY I WILL MAKE A 5; THIS IS THE WAY I WILL MAKE A 6. If the subject gives any indication that he makes the numbers differently from the examiner, the examiner's method should be adapted to the subject's method for writing the numbers. In some instances it is worthwhile to have the subject write the numbers 3, 4, 5, 6, on paper before the illustrations are given on the subject's palm, so that the numbers can be made in the way most familiar to the subject.

BE SURE TO KEEP YOUR EYES CLOSED BUT PAY CLOSE ATTENTION SO THAT YOU WILL BE ABLE TO TELL WHAT NUMBERS I WRITE. SINCE I AM FACING YOU, REMEMBER THAT THE NUMBERS I WILL BE WRITING ARE UPSIDE DOWN.

Shield the patient's fingers as you write each number so that he will not be able to see what is written even if he should open his eyes. Use a different finger for each trial (proceeding from finger #1 through #5) until four trials have been given (using the numbers indicated on the test form) for each finger of the right hand. Duplicate the procedure for the left hand. Record only errors (Reitan, 1975).

FINGERTIP NUMBER IDENTIFICATION (Armstrong-Whitehouse): The S was shown the numbers 3, 4, 5 and 6, and told that they were easily identified by sight but on this test the numbers

would be identified by touch only. Identification by touch could be more difficult since numbers are not normally identified by touch. For the test, the experimenter placed one of the S's fingers on a number. The S could use only that finger to identify the number. The S put on the goggles after the directions were understood. The experimenter held the number immobile and in a position such that the number was right side up if the S was looking at it while the S felt the number. For Ss that could not move their fingers, the experimenter moved the numbers for the S. A different finger was used for each trial starting with the first finger of the right hand. The order of presentation is given in Table 4. Duplicate the procedure for the left hand. Only errors were recorded.

Table 4

The order of presentation for the Fingertip Number Identification Subtest.

	Finger				
	First	Second	Third	Fourth	Fifth
Right	4 6 3 5	3 5 4 6	6 5 4 3	5 4 6 3	6 3 5 4
Left	4 6 3 5	3 5 4 6	6 5 4 3	5 4 6 3	6 3 5 4

TACTILE IDENTIFICATION

COIN RECOGNITION (Reitan-Klove): I AM GOING TO PUT SOMETHING IN YOUR HAND (begin with right hand). FEEL IT CAREFULLY AND TELL ME WHAT IT IS. BE SURE TO KEEP YOUR EYES CLOSED BECAUSE I WANT YOU TO DEPEND UPON TOUCH ALONE. Alternate the two hands on successive trials and use coins in the sequence indicated on the test form. NOW I WILL PUT AN OBJECT IN YOUR OTHER HAND AND YOU TELL ME WHAT IT IS. Proceed in a like manner with remaining coins.

After completing the trials with each hand separately, proceed by putting the same coin in each hand simultaneously but without letting the patient know that identical objects are being used. Say: NOW I AM GOING TO PUT SOMETHING IN BOTH HANDS AT THE SAME TIME. SEE IF YOU CAN TELL ME WHAT THEY ARE.

The subject should not be permitted to hit or rub the coins on the table but should be required to use tactile perception alone. It should not be necessary for the subject to feel the coins for more than 30 seconds (Reitan, 1975).

Reitan and Klove found that coins are not ideal for systematic investigation of tactile form perception for a number of reasons. The tactile form recognition test was therefore devised and used for showing differences in stereognosis. The major value of the results from the tactile form recognition test are derived from the speed of response since errors occur rarely. When errors do occur, they may represent important signs of deficit.

TACTILE FORMS RECOGNITION (Reitan-Klove): The purpose of this test is to test tactile form discrimination in the two hands. The right hand is tested first regardless of the patient's handedness, using all four figures, then the left hand, the right hand again, and finally the left hand. The order of presentation of the figures is as follows: Right hand: circle, square, triangle, cross. Left Hand: triangle, cross, circle, square. Right hand: cross, circle, square, triangle. Left hand: square, triangle, cross, circle. The hand not being tested is used to indicate the response by pointing to one of the four figures displayed on the face of the board.

The subject is permitted to feel the figure as long as he needs to in order to identify the figure, but he is encouraged to respond as quickly as possible because each response is timed. The time for each response is recorded in seconds and the total of the eight trials for each hand is determined. In giving the test, do not allow the subject to remove the hand being tested from the board until all four trials have been completed and be sure that the subject does not see the figure when it is placed in his hand. Place the figure toward the subject's fingertips rather than in the middle of his palm.

Have the subject place his right hand through the hole in the board. I AM GOING TO PLACE AN OBJECT IN YOUR HAND. FEEL IT CAREFULLY, THEN POINT WITH YOUR LEFT HAND TO THE

FIGURE ON THE BOARD (examiner points to the row of figures on the front of the board) WHICH IS JUST LIKE THE ONE IN YOUR HAND. BE SURE TO SHOW ME THE RIGHT FIGURE AS QUICKLY AS YOU CAN. Examiner places first figure (circle) in the subject's right hand. After the subject's response, remove the figure from the hand and place the next figure (square) in the same hand. The sequence of the first series, using the right hand, is circle, square, triangle and cross. After each response, record the time in seconds required for the response and, if the response is incorrect, note the figure mistakenly identified. If the subject makes an incorrect response that is clearly due to carelessness, poor motor control, or some other similar factor, it should not be counted as an error. However, even an immediate correction by the patient of a genuine error should not overrule the fact that the error occurred, even though the examiner should make a note of the spontaneous correction. Verbal responses are permissable only if the patient is clearly handicapped in making the required motor response.

After completing the first series with the right hand, say: YOU MAY TAKE THAT HAND OUT NOW, AND PUT IN YOUR LEFT HAND. WE WILL DO THE SAME THING USING YOUR LEFT HAND. FEEL THE OBJECT WITH YOUR LEFT HAND, AND POINT TO THE CORRECT FIGURE WITH YOUR RIGHT HAND. BE SURE TO SHOW ME THE RIGHT FIGURE AS QUICKLY AS YOU CAN. Place the figure (triangle) in the subject's hand, and proceed as above. The sequence

is triangle, cross, circle, and square. Next, the right hand is tested again (cross, circle, square, triangle), followed by a second series with the left hand (square, triangle, cross, circle). The total number of mistakes for each hand is recorded as well as the total time required for each hand (Reitan, 1975).

RAISED DESIGN (Armstrong-Whitehouse): A rack of five designs was placed in front of the S. The S was instructed, "Here we have five different designs. For this test, I will pick a design and place it in your palm for five seconds, and then I will place it back on the rack with the other designs. Each time I will mix up the order of the designs in the rack. Next I will place your hand on the end design. You can touch each design with your palm or fingertips, whichever you prefer, then point out to me which design was in your hand. Before we start the test, I'll place each design in your right hand for five seconds so you'll have an idea of how each design feels in your hand." Each design was placed in the S's right palm, regardless of handedness, for five seconds. After the S understood the test instructions, the S was asked to put on the goggles.

The sample design was placed on the right palm for five seconds. The same hand used to feel the sample was placed on the end design. The S then examined the five comparison designs with either the palm or fingertips of the right hand and selected the design that seemed to be identical to

the sample. First the right hand was tested then the left. The order of presentation of the sample designs was the same for all Ss: Right: X, O, Z, [ ], П Left: [ ], Z, X, П, O The comparison designs were placed in random order for each S. The number of errors was recorded for each hand.

AUDITORY PERCEPTION

AUDITORY IMPERCEPTION (Reitan-Klove): NOW I'M GOING TO STAND BEHIND YOU AND MAKE A NOISE LIKE THIS (a barely audible finger snap - just rubbing two fingers together should be sufficient). I WANT YOU TO TELL ME IF THE SOUND YOU HEAR IS BY THIS EAR (touch the right ear) OR BY THIS EAR (touch the left ear). YOU CAN TELL ME WHICH EAR BY SAYING "RIGHT" OR "LEFT". BE SURE TO KEEP YOUR EYES CLOSED. Use the above instruction for tactile stimulation as a model for completing this test, interspersing unilateral with bilateral stimulation (Reitan, 1975).

AUDITORY PERCEPTION (Armstrong-Whitehouse): "Now I'm going to stand behind you and make a noise like this (tap the tuning fork). I want you to tell me if the sound is by this ear (touch the right ear) or by this ear (touch the left ear) or both ears. You can tell me which ear by saying 'Right' or 'Left'. Be sure to keep your eyes closed."

Sound the tuning forks about three inches from the right ear, left ear, or both ears simultaneously in random order until each has been tried at least four times. If the S has difficulty hearing the stimulus on one side or the other, this should be recorded. The important point of this test

is to determine whether or not the S fails to respond to one side consistently with bilateral simultaneous stimulation error though the S responds correctly on the same side with unilateral stimulation.

Both the Reitan-Klove Sensory-Perceptual Examination and the Armstrong-Whitehouse Sensory-Perceptual Examination were given to all subjects. Each examination was presented as a complete unit, then the other examination was given. The order of presentation was randomized.

CHAPTER III

RESULTS

To evaluate the reliability of either the Reitan-Klove Examination or the Armstrong-Whitehouse Examination for discriminating between brain damaged and non-brain-damaged subjects, the discriminative functioning of each subtest must be established. The discriminative functioning of all subtests is based on the occurrence of false positives and false negatives. A false positive occurs when a non-brain-damaged subject is classified brain damaged. A false negative occurs when a brain damaged subject is classified non-brain-damaged. The objective of differential diagnosis through psychological testing is correct classification of subjects. However, with current technology, it is not possible to have perfectly correct classifications. Therefore, in practice, a very low to zero rate of false positives is the most important criterion. Following this criterion, cut off scores which best separate brain damaged and non-brain-damaged subjects are established for each subtest based on the frequency distributions, even though the cut off score may permit false negatives.

In the following paragraphs, the frequency distribution and cut off scores will be presented for each subtest. The cut off score will show the percent of false positives and

false negatives when the errors on the left and right hand are combined. The Reitan-Klove subtest data will be presented and followed by the Armstrong-Whitehouse subtests that were assumed to test the same process.

TACTILE PERCEPTION

The tactile perception category includes one Reitan-Klove subtest and two Armstrong-Whitehouse subtests, pressure sensitivity and two point discrimination.

TACTILE IMPERCEPTION: The frequency distribution and cut off scores with the resulting percent of correct and incorrect classifications for this Reitan-Klove subtest are presented in Table 5. If the cut off score is set at one error, the rate of false positives is zero and the rate of false negatives is 46%.

Table 5

The frequency distribution and cut off scores for the Reitan-Klove Tactile Imperception subtest

Score	Control	Experimental
9[a]	0	9
8	0	3
7	0	0
6	0	5
5	0	4
4	0	5
3	0	4
2	0	2
1	0	5
0	68	31

1	Control	Experimental
above	0%	54%
below	100%	46%

[a]Nine or more errors.

PRESSURE SENSITIVITY: The frequency distribution and cut off scores for this Armstrong-Whitehouse subtest are presented in Table 6. If the cut off score is set at four or more errors, the rate of false positives is 10% and the rate of false negatives is 38%.

Table 6

The frequency distribution and cut off scores for the Armstrong-Whitehouse Pressure Sensitivity subtest

Score	Control	Experimental
11	0	23
10	0	1
9	0	6
8	0	4
7	0	4
6	0	10
5	3	11
4	11	25
3	28	29
2	59	19
1	35	4

4	Control	Experimental
above	10%	62%
below	90%	38%

TWO POINT DISCRIMINATION: The frequency distribution and cut off scores for this Armstrong-Whitehouse subtest are presented in Table 7. If the cut off score is set at 10 or more errors, the resulting rate of false positives is 1% and the rate of false negatives is 54%.

Table 7

The frequency distribution and cut off scores
for the Armstrong-Whitehouse
Two Point Discrimination subtest

Score	Control	Experimental
32	0	30
31	0	0
30	0	1
29	0	0
28	0	0
27	0	1
26	0	0
25	0	0
24	0	1
23	0	1
22	0	0
21	0	0
20	0	0
19	0	1
18	0	0
17	0	1
16	0	2
15	0	4
14	0	5
13	0	3
12	0	1
11	0	6
10	2	5
9	6	8
8	6	11
7	21	12
6	41	19
5	33	6
4	15	10
3	9	6
2	3	0
1	0	1
0	0	0

	Control	Experimental
above 10	1%	46%
below	99%	54%

FINGER AGNOSIA

The finger agnosia category includes one Reitan-Klove subtest and one Armstrong-Whitehouse subtest.

FINGER AGNOSIA: The frequency distribution and cut off scores for this Reitan-Klove subtest are presented in Table 8. If the cut off score is set at two or more errors, the resulting rate of false positives is 7% and the rate of false negatives is 40%.

Table 8

The frequency distribution and cut off scores for the Reitan-Klove Finger Agnosia subtest

Score	Control	Experimental
20	0	9
19	0	0
18	0	0
17	0	0
16	0	0
15	0	0
14	0	0
13	0	0
12	0	0
11	0	1
10	0	0
9	0	1
8	0	2
7	0	3
6	0	1
5	1	2
4	1	5
3	1	8
2	2	9
1	11	8
0	52	19

2	Control	Experimental
above	7%	60%
below	93%	40%

FINGER AGNOSIA: For this Armstrong-Whitehouse subtest, the frequency distribution and cut off scores are presented in Table 9. There is a rate of 3% false positives and a rate of 53% false negatives if the cut off score is set at three or more errors.

Table 9

The frequency distribution and cut off scores for the Armstrong-Whitehouse Finger Agnosia Subtest

Score	Control	Experimental
20	0	7
19	0	0
18	0	1
17	0	1
16	0	0
15	0	0
14	0	0
13	0	0
12	0	0
11	0	1
10	0	1
9	0	0
8	0	0
7	0	1
6	0	4
5	0	5
4	0	6
3	2	5
2	4	5
1	4	11
0	58	20

		Control	Experimental
above	3	3%	47%
below	3	97%	53%

FINGERTIP IDENTIFICATION

The fingertip identification category includes the Reitan-Klove fingertip number writing perception subtest and the Armstrong-Whitehouse fingertip number writing subtest.

FINGERTIP NUMBER WRITING PERCEPTION: The frequency distribution and cut off scores for this Reitan-Klove subtest are shown in Table 10. If the cut off score is set at four or more errors, the rate of false positives is 7% and the rate of false negatives is 24%.

Table 10

The frequency distribution and cut off scores for the Reitan-Klove Fingertip Number Writing Perception subtest.

Score	Control	Experimental
20	0	8
19	0	1
18	0	1
17	0	0
16	0	1
15	0	1
14	0	2
13	0	2
12	0	5
11	0	6
10	0	9
9	0	2
8	0	3
7	0	3
6	1	3
5	1	3
4	3	2
3	2	4
2	8	4
1	17	7
0	36	1

4	Control	Experimental
above	7%	76%
below	93%	24%

FINGERTIP NUMBER IDENTIFICATION: On the Armstrong-Whitehouse subtest, the frequency distribution and cut off scores are presented in Table 11. If the cut off score is set at five or more errors, the rate of false positives is 10% and the rate of false negatives is 12%.

Table 11

The frequency distribution and cut off scores for the Armstrong-Whitehouse Fingertip Number Identification subtest.

Score	Control	Experimental
20	0	13
19	0	2
18	0	2
17	0	5
16	0	3
15	0	5
14	0	3
13	0	2
12	0	3
11	0	1
10	2	5
9	2	4
8	0	3
7	0	5
6	2	2
5	1	2
4	3	2
3	3	1
2	9	2
1	11	2
0	35	1

		Control	Experimental
above	5	10%	88%
below		90%	12%

TACTILE IDENTIFICATION

The tactile identification category includes Reitan-Klove's coin recognition and tactile forms subtests. Also included in this category is the Armstrong-Whitehouse raised designs subtest.

COIN RECOGNITION: This Reitan-Klove subtest's frequency distribution and cut off scores are presented in Table 12. The rate of false positives is 7% and the rate of false negatives is 35% if the cut off score is set at three or more errors.

Table 12

The frequency distribution and cut off scores for the Reitan-Klove Coin Recognition subtest

Scores	Control	Experimental
6	0	17
5	0	6
4	1	8
3	4	13
2	19	11
1	25	7
0	19	6

3	Control	Experimental
above	7%	65%
below	93%	35%

TACTILE FORMS: This Reitan-Klove subtest of time and errors has a frequency distribution and cut off scores presented in Tables 13 and 14, respectively. On the tactile forms-time subtest, if the cut off score is set at 20 or more seconds (total time of test), the rate of false positives is 9% and the rate of false negatives is 19%. If the cut off score is set at one or more errors for the tactile forms-errors (total number of errors for the test), the rate of false positives is 4% and the rate of false negatives is 43%.

Table 13

The frequency distribution and cut off scores
for the Reitan-Klove
Forms-Time subtest.

Seconds	Control	Experimental		
120	0	16	above	
110-119	0	1		
100-109	0	2		20
90- 99	0	0	below	
80- 89	0	1		
70- 79	0	1		
60- 69	0	4		
50- 59	0	2		
40- 49	0	11		
30- 39	0	6		
20- 29	6	11		
10- 19	53	13		
0- 9	9	0		

	Control	Experimental
above	9%	81%
below	91%	19%

Table 14

The frequency distribution and cut off scores
for the Reitan-Klove
Forms-Errors subtest

Errors	Control	Experimental		
8	0	16	above	
7	0	1		
6	0	4		1
5	0	1	below	
4	0	3		
3	0	1		
2	0	4		
1	3	9		
0	65	29		

	Control	Experimental
above	4%	57%
below	96%	43%

RAISED DESIGN: The frequency distribution and cut off scores for this Armstrong-Whitehouse subtest are presented in Table 15. If the cut off score is set at four or more errors, the rate of false positives is 3% and the rate of false negatives is 41%.

Table 15

The frequency distribution and cut off scores for the Armstrong-Whitehouse Raised Design subtest

Score	Control	Experimental
5	0	20
4	2	20
3	20	15
2	19	5
1	20	3
0	7	5

	Control	Experimental
above 4	3%	59%
below	97%	41%

AUDITORY PERCEPTION

The auditory perception category includes one Reitan-Klove subtest and one Armstrong-Whitehouse subtest.

AUDITORY IMPERCEPTION: For this Reitan-Klove subtest, the frequency distribution and cut off scores are presented in Table 16. If the cut off score is set at one or more errors, the rate of false positives is 6% and the rate of false negatives is 59%.

Table 16

The frequency distribution and cut off scores for the Reitan-Klove Auditory Imperception subtest.

Score	Control	Experimental
8[a]	0	5
7	0	2
6	0	1
5	0	1
4	0	4
3	0	0
2	2	6
1	2	9
0	64	40

		Control	Experimental
above	1	6%	41%
below		94%	59%

AUDITORY PERCEPTION: The frequency distribution and cut off scores for this Armstrong-Whitehouse subtest are presented in Table 17. If the cut off score is set at three or more errors, the rate of false positives is 3% and the rate of false negatives is 57%.

Table 17

The frequency distribution and cut off scores for the Armstrong-Whitehouse Auditory Perception subtest.

Score	Control	Experimental
8[a]	0	4
7	0	3
6	0	5
5	0	2
4	0	6
3	2	9
2	11	12
1	27	9
0	28	18

		Control	Experimental
above	3	3%	43%
below		97%	57%

[a]eight or more errors.

To help determine the discriminative validity of the Reitan-Klove Examination and the Armstrong-Whitehouse Examination, the concept of Halstead's impairment index was utilized. The impairment index for an examination was based on the total number of tests in the test battery on which the subject was classified brain damaged. The number of subtests which tends to divide the brain damaged from the non-brain-damaged subjects with the least overlap of the two groups was set as the impairment index. For the highest predictive validity, emphasis was again placed on obtaining the smallest number of false positives and false negatives. By applying the impairment index to the original subjects, there is some contamination which produces an increase in the power of the tests for predicting the subject's classification. However, this is assumed to be minor and the tests are still highly predictive.

The distribution of the number of subtests that predict brain damage on the Reitan-Klove Examination are presented in Table 18. Comparisons of the performances of the brain damaged and control groups reveal major differences in the distribution of the number of subtests predicting brain damage. If the impairment index is set such that the subject obtaining four or more subtests predicting brain damage in the test battery is classified brain damaged, no subject in the control group is classified brain damaged. With this impairment index, the examination has no misclassifications of the

control group while there are two subjects (6%) of the experimental group misclassified and labeled non-brain-damaged.

Table 18

The frequency distribution and cut off scores for the Reitan-Klove Examination

Number of tests	Control	Experimental
7	0	11
6	0	9
5	0	4
4	0	8
3	3	1
2	8	1
1	21	0
0	2	0

4

	Control	Experimental
above	0%	94%
below	100%	6%

For the Armstrong-Whitehouse Examination, Table 19 presents the frequency distribution and cut off scores of the subtests predicting brain damage. There are major differences in the distributions of the subtests predicting brain damage when the two groups are compared. If the impairment index is set such that a subject with three or more subtests predicting brain damage is classified as brain damaged, none of the control group is misclassified while two experimental subjects (6%) are misclassified.

Table 19

The frequency distribution and cut off scores for the Armstrong-Whitehouse Examination

Number of tests	Control	Experimental
6	0	11
5	0	11
4	0	6
3	0	4
2	6	1
1	10	1
0	18	0

	Control	Experimental
above 3	0%	94%
below	100%	6%

CHAPTER IV

DISCUSSION

The first purpose of this study was to obtain validation data to evaluate the Reitan-Klove Sensory-Perceptual Examination as a discriminator between normal and brain damaged subjects. Cut off scores for each subtest of the examination were established and the subtests were used to establish a cut off score for the test battery. This cut off score or impairment index was based on the number of tests which classified subjects brain damaged. The number of subtests which divided brain damaged from non-brain-damaged subjects with the least overlap was the impairment index. The impairment index for the Reitan-Klove Examination was set at four subtests. The number of control subjects with four or more tests which classified them as brain damaged was zero and the number of experimental subjects with four or more subtests classifying them as brain damaged was 94%. There were no false positives and a low occurrence of false negatives (6%). Therefore, the Reitan-Klove Examination can distinguish between brain damaged and non-brain-damaged subjects.

A second purpose of this study was to evalute an alternative procedure for assessing sensory perceptual status

based on the variables of the Reitan-Klove Examination. The alternative procedure, the Armstrong-Whitehouse Sensory-Perceptual Examination, was more standardized procedurally than the Reitan-Klove Examination. Evaluation of the Armstrong-Whitehouse Examination based on the concept of the impairment index reveals high discriminative validity. When the impairment index was set at three or more subtests predicting brain damage, none of the control subjects were diagnosed brain damaged and 94% of the brain damaged group were correctly diagnosed brain damaged while 6% were incorrectly diagnosed. There were no false positives and a small incidence of false negatives. Thus, the Armstrong-Whitehouse Examination can distinguish between brain damaged and non-brain-damaged subjects.

A third purpose of this study was to determine if procedural standardization would improve the discriminative validity of a sensory perceptual examination. The Armstrong-Whitehouse Examination was based on the variables of the Reitan-Klove Examination but it was more standardized procedurally. Therefore, if the Armstrong-Whitehouse Examination had better discriminative validity than the Reitan-Klove Examination, procedural standardization would increase the discriminative validity of sensory-perceptual examinations. Inspection of the impairment index for both examinations indicates there is no major difference in the discriminative validity of the examinations; both are excellent discriminators. To check for increased discriminative

validity among subtests, each subtest should be compared. The Reitan-Klove Examination should be compared to the Armstrong-Whitehouse Examination on subtests which examine the same variables but are procedurally standardized.

TACTILE PERCEPTION

The tactile imperception subtest (Reitan-Klove) had the lowest occurrence of false positives, zero, but at the same time had a large occurrence of false negatives, 46%. The two point discrimination subtest (Armstrong-Whitehouse) had the next lowest occurrence of false positives, 1%, but had a very high occurrence of false negatives, 54%. The pressure sensitivity subtest (Armstrong-Whitehouse) had the highest occurrence of false positives, 10%, among the three tests however 10% is an acceptable rate of false positives. The occurrence of false negatives on this subtest was the lowest of the three subtests at 38%. Therefore, considering the occurrence of false positives and false negatives, the pressure sensitivity subtest appears to be the best discriminator.

FINGER AGNOSIA

The finger agnosia (Reitan-Klove) has an occurrence of false positives at 7% and an occurrence of false negatives at 41%. The finger agnosia (Armstrong-Whitehouse) has a false positive rate of 3% and a false negative rate of 53%. Both tests have relatively low rates for false positives but have very large rates of false negatives. Therefore it is hard to state that one test is a better discriminator than the other. Both have some discriminating value but neither are

exceptionally good discriminators.

FINGERTIP IDENTIFICATION

The fingertip number writing perception subtest (Reitan-Klove) has a rate of 7% for false positives and a rate of 24% for false negatives. The fingertip number identification subtest (Armstrong-Whitehouse) has a rate of 5% false positives and a rate of 15% for false negatives. Both tests appear to be good discriminators; however the Armstrong-Whitehouse subtest seems to be the better discriminator of the two tests.

TACTILE IDENTIFICATION

The raised design (Armstrong-Whitehouse) subtest has the lowest rate of false positives, 3%, but it has a high rate of false negatives, 41%. The tactile forms-errors subtest (Reitan-Klove) has the next lowest rate of false positives, 4%, but has the highest rate of false negatives, 43%. The next highest occurrence of false positives is 7% on the coin recognition subtest (Reitan-Klove) with a relatively low rate of false negatives, 35%. The highest rate of false positives among these four is the tactile forms-time (Reitan-Klove) at 9%. The rate of false negatives is the lowest among these four subtests on this subtest at 19%. Among these four subtests the best discriminator appears to be the tactile form-time subtest.

AUDITORY PERCEPTION

The auditory imperception subtest (Reitan-Klove) has a rate of false positives at 6% and a rate of false negatives at 59%. The auditory perception subtest (Armstrong-Whitehouse) has a rate of false positives at 3% and a rate of false negatives at 57%. Both subtests have relatively low rates of false positives but excessively high rates of false negatives. Neither subtest appears to be a good discriminator.

The tests dealing with auditory perception and finger agnosia appear to be the least adequate tests for predicting brain damage. Therefore, the best discriminators are: pressure sensitivity (Armstrong-Whitehouse), fingertip number identification (Armstrong-Whitehouse), and tactile forms-time (Reitan-Klove).

Procedural standardization improved the discriminative validity in two out of three areas. It seems that in some cases procedural standardization would increase the discriminative validity. Some possibilities which might mask the effect of procedural standardization could include type of brain damaged population used, age of subjects, and the sex of subjects.

The brain damaged population of this study were all long term hospitalized patients. Therefore it is possible that there was not a greater discrepancy in dicriminative validity between the two procedures because the experimental group was extensively brain damaged and even a vague test

for brain damage would have revealed that fact. Perhaps an experimental group consisting of less severely brain damaged subjects would reveal that procedural standardization would increase the sensory-perceptual examination's discriminative validity because it would need a better instrument to separate the two groups when they are closer together in brain-behavior functioning.

Another possibility to increase the discriminative validity of the procedurally standardized examination is discriminating between brain damaged and non-organic psychotics. Here also a better instrument would be needed to distinguish between brain damaged and psychotic subjects because both exhibit behavior problems that could be organic.

Although age differences would not be expected to affect the discriminative validity of the functions in the present study, age differences could account for the discrepancy in Boll's (1972) findings cited earlier. In this study there is a difference in mean ages of the two groups of nine years. However, this should not affect the difference in performance of the two groups. If there were a decline in sensory perceptual processes, it would be expected to occur in the late 60's or early 70's as it occurs in intellectual functioning (Kinsborne, 1977). The oldest persons in the study were 64 years of age. Therefore, the author assumed that sensory perceptual processes are least affected by age and thus age should not be a factor affecting the test performance among adults.

No sex difference would be expected among sensory perceptual processes. One might infer from the pain studies that women would have lower thresholds and would do better on these examinations. However, recent research in pain indicates that personality factors, such as hysteria, affect these processes rather than gender. Since a short medical history was taken on the control subjects, there was reason to assume that there were no hysterics or somotasizers in the group. Therefore, the author assumed that age and gender factors had no effect on the performance of the subtests.

SUMMARY

Based on the data evaluated in this study, the Reitan-Klove Sensory-Perceptual Examination is a valid test for discriminating between brain damaged and non-brain-damaged subjects. The Armstrong-Whitehouse Sensory-Perceptual Examination is also a valid test which can discriminate between brain damaged and non-brain-damaged subjects. The results of this study do not confirm or deny the expectation that procedural standardization of sensory perceptual examinations will improve their ability to discriminate among brain damaged and non-brain-damaged subjects. However, in some areas, such as tactile perception and fingertip number identification, there are indications that procedural standardization does increase the discriminative ability of the test.

REFERENCES

Boll, J. T., & Reitan, R. M. Motor and tactile perceptual deficits in brain-damaged children. Perceptual and Motor Skills, 1972, 34, 343-350.

Ghent, L., Weinstein, S., Semmes, J., & Teuber, H-L. Effect of unilateral brain injury in man on learning of a tactual discrimination. Journal of Comparative and Physiological Psychology, 1955, 48, 478-81.

Goldstein, K. The organism. A holistic approach. New York: American Book Co., 1939.

Kinsbourne, B. M. Cognitive decline with advancing age: An interpretation. In W. L. Smith & B. M. Kinsbourne (Eds.), Aging and dematia. New York: Spectrum Publications, Inc., 1977.

Lezak, M. D. Neurological assessment. New York: Oxford University Press, 1976.

Matarazzo, J. D. Weschsler's measurement and appraisal of adult intelligence (5th ed.). Baltimore: Williams and Wilkins Co., 1972.

Reider, N. Phenomena of sensory suppression. Archives of Neurology and Psychiatry, 1946, 55, 583-590.

Reitan, R. M. An investigation of the validity of Halstead's measures of biological measures. Archives of Neurology and Psychiatry, 1955, 73, 28-35.

Reitan, R. M. An overview of psychological testing. In P. R. Fransworth, Annual review of psychology. Palo Alto, California, 1962.

Reitan, R. M. Problems and prospects in studying the psychological correlates of brain lesions. Cortex, 1966, 2, 127-154.

Reitan, R. M. Clinical neuropsychology: Current status and applications. Washington, D.C.: V. H. Winston & Sons, 1974.

Reitan, R. M. Manual for administration of neuropsychological test batteries for adults and children. Privately published by the author, Seattle, Washington, 1975.

Semmes, J. Hemispheric specialization: A possible clue to mechanism. Neuropsychologia, 1968, 6, 11-26.

Semmes, J., Weinstein, S., Ghent, L., & Teuber, H-L. Somatosensory changes after penetrating brain wounds in man. Cambridge, Mass.: Harvard University Press, 1960.

Smith, A. Ambiguity in concepts and studies of "brain damaged" "organicity". In W. L. Smith & M. J. Philippus (Eds.), Neuropsychological testing in organic brain dysfunction. Springfield: Thomas, 1969.

Teuber, H-L. Some alternations in behavior after cerebral lesions in man. In A. D. Bass (Ed.), Evolution of nervous control from primitive organisms to man. Washington, D.C.: American Association for the Advancement of Science, 1959.

Teuber, H-L., Battersby, W. S., & Bender, M. B. Visual field defects after penetrating missile wounds of the brain. Cambridge, Mass.: Harvard University Press, 1960.

Verillo, R. T. Cutaneous sensation. In B. Scharf (Ed.), Experimental sensory psychology. Glenview, Illinois: Scott Foreman and Co., 1975.